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URBANA

REPORT OF INVESTIGATIONS—NO. 98

SMALLER FORAMINIFERA FROM THE PORTERS CREEK FORMATION (PALEOCENE) OF ILLINOIS

BY

CHALMER L. COOPER

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Topographic Mapping in Cooperation with the United States Geological Survey.
This report is a Contribution of the Stratigraphy and Paleontology Section.

May 15, 1944

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SMALLER FORAMINIFERA FROM THE PORTERS CREEK FORMATION (PALEOCENE) OF ILLINOIS

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Abstract—A microfauna of smaller Foraminifera from the cuttings of a water well in Cache, southern Alexander County, shows the occurrence of Lower Eocene (Paleocene) sediments almost to the northern limit of the Mississippi embayment. Six families are represented, comprising 15 genera and 30 species. More than half of the species belong to the Lagenidae, with two to four species in each of the Heterohelicidae, Ellipsoidinidae, Rotaliidae, Globigerinidae, and Anomalinidae. Two new species are described.

INTRODUCTION

The original northern limit of Tertiary sediments in the Mississippi embayment is unknown. The Cretaceous deposits in the Mississippi Valley probably extended as far north as southeastern Minnesota (Sardeson, 1898) and may have been at one time coextensive with those of the Mid-continent region. To a certain extent the succeeding Paleocene sea flooded the same areas. Therefore it is probable that the earliest Cenozoic formations originally extended farther north than the present outcrops in southern Illinois would indicate. On the other hand, shore line conditions are indicated by the absence of some marine horizons which are present farther south. In Tennessee the Ripley group is composed of the McNairy sand over- and underlain by the Owl Creek and Coon Creek marine formations. The last two formations are not recognized in Kentucky and from the very sandy and glauconitic character of the Ripley in Illinois it is possible that only the McNairy is present here also. The possibility should be pointed out that the shoreward nonfossiliferous phases of these higher and lower formations would take on the sandy characteristics of the McNairy and would therefore be indistinguishable from it.

The same is true of the Wilcox group. In Tennessee it is composed of the Holly Springs sandy formation which is over- and underlain by the Grenada and Ackermann marine shaly and limy formations. The latter is not recognized in Kentucky and from the sandy character of the Wilcox at the northern limit of its outcrop the Grenada is probably also absent. This would leave the Holly Springs as the sole representative of the Wilcox group at the northern end of the embayment, although the possible presence of the sandy shoreward phase of the other members of the group must not be overlooked.

The northernmost outcrop of Paleocene formations shown on the geologic map of the United States (Stose, 1932) is found on the eastern side of the Mississippi embayment just south of the Kentucky line in the north-central part of Henry County, Tennessee. On the west side of the embayment the most northern extent of the Midway is shown southeast of Newport in northeastern White and southeastern Independence counties, Arkansas. However, Lamar and Sutton (1930, fig. 1) mapped the Porters Creek formation around the eastern and northern edges of the embayment across Kentucky and into Alexander County, Illinois, as far west as the town of Unity where the formation dips beneath younger sediments. They also mentioned (p. 953) the possible occurrence of the formation at Idalia and Bloomfield, central Stoddard County, Missouri. However, no correlation of the Porters Creek of Illinois, other than with the formation in Tennessee, was made by these writers. Subsequent work has confirmed the suspected occurrences and revealed others in Missouri (Farrar and McManamy, 1937; Stewart, McManamy, and McQueen, 1943) and has shown that a number of changes are necessary in the Illinois portion of the map (see text fig. 1).

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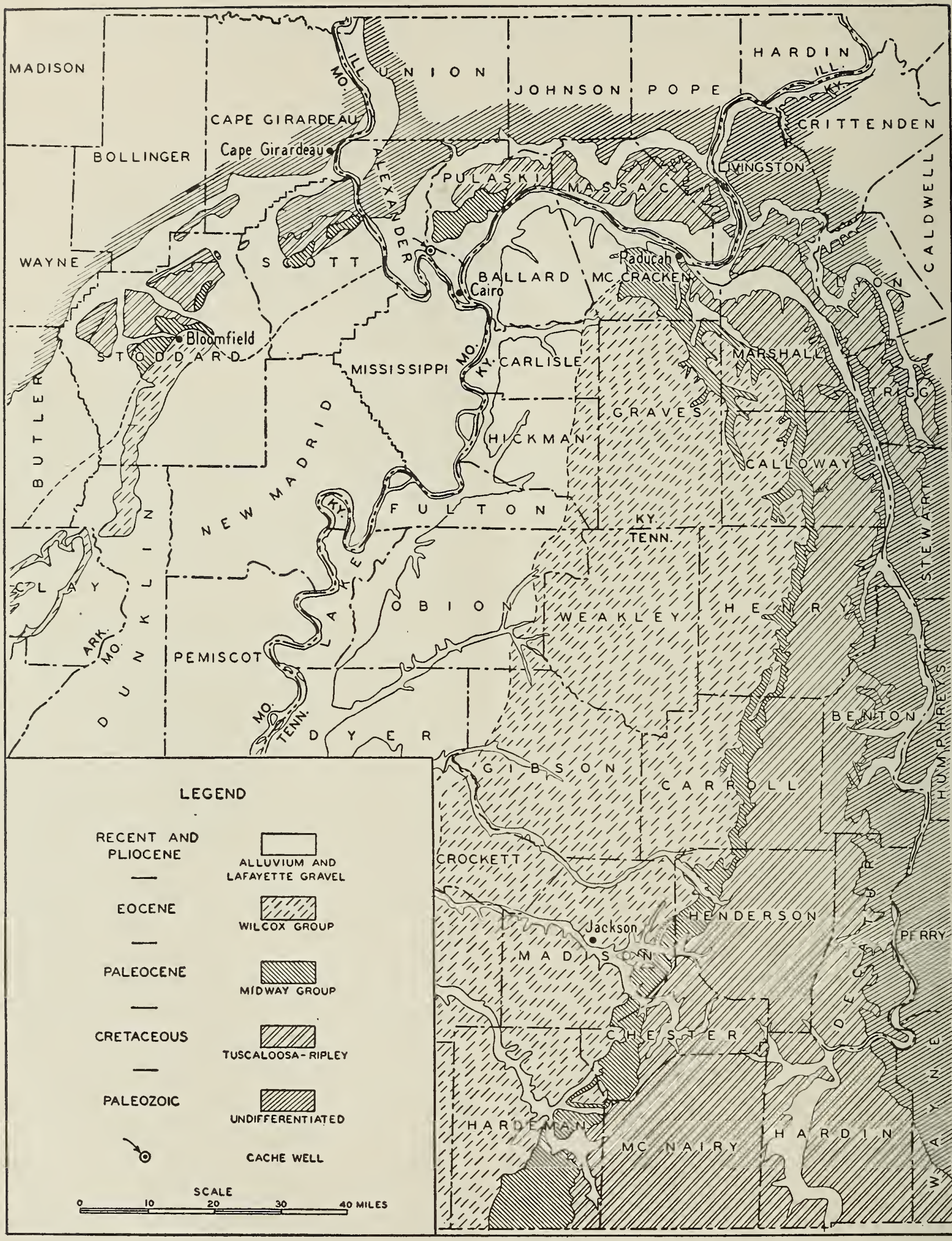


FIG. 1.—Map of the upper part of the Mississippi embayment area showing the outcrop of the Wilcox and Midway groups and the location of the well at Cache, Alexander County, Illinois.

From geologic maps of Tennessee (1923), Kentucky (1929), Illinois (1939), and Missouri (1939, revised by recent work of the Missouri Geological Survey).

The formation containing the fossils described was named the "Porters Creek group" for exposures on Porters Creek, Hardemann County, Tennessee, by Stafford (1864, p. 368) where it has a thickness of 200 to 300 feet. There it overlies the Clayton formation, which together with the Porters Creek, comprises the Midway group of the central and northern embayment areas and underlies the Ackerman formation of Wilcox age. Harris (1896) first correlated the formation with the Midway.

The Cretaceous and Tertiary sediments in the northern part of the embayment in Illinois and Missouri are almost completely devoid of calcareous material and fossil remains, except for an occasional fossil cast. Lamar and Sutton (1930, p. 848) believe the original calcareous material, while once present in the sediments, has been removed by leaching.

The microfauna described was obtained from the cuttings of a water well drilled in 1938 at Cache, Illinois, in SE¼ SE¼ SW¼ sec. 19, T. 16 S., R. 1 W., Alexander County. The well was drilled for O. R. Bourland by E. M. Gould, who furnished a driller's log and 5-foot samples of the drill cuttings to the Subsurface Division of the Illinois State Geological Survey, where they were studied and described by Earl C. Cochrum. It was Mr. Cochrum who called my attention to the occurrence of the numerous Foraminifera found in the samples from a depth of 115 to 135 feet. All but four of the species described came from the two sam-

Correlation of Post-Paleozoic Sediments in the Upper Mississippi Embayment Area

AGE	ARKANSAS	TENNESSEE[1]		KENTUCKY[2]	ILLINOIS		MISSOURI[3]	
RECENT AND/OR PLEISTOCENE	Alluvium and Loess	Alluvium and Loess		Alluvium and Loess	Alluvium and Loess		Alluvium and Loess	
PLIOCENE	Gravel	Gravel		Lafayette	"Lafayette"		Gravel	
EOCENE	Jackson	Jackson		Jackson				
	Claiborne							
	Wilcox	WILCOX	Grenada Holly Springs	Grenada Holly Springs	Wilcox		Wilcox	
			Ackerman					
PALEOCENE	Midway	MIDWAY	Porters Creek	Porters Creek	Porters Creek		Porters Creek	
			Clayton		Clayton		Clayton	
CRETACEOUS	Nacatoch	RIPLEY	Owl Creek McNairy	McNairy	RIPLEY	McNairy	RIPLEY	Owl Creek McNairy Coon Creek?
			Coon Creek					
		Selma		Selma			Selma (?)	
		Eutaw		Eutaw			Eutaw (?)	
		Tuscaloosa		Tuscaloosa				

[1] Whitlatch (1940);
[2] McFarlan (1943);
[3] Kansas Geol. Soc. (1939) and Stewart, McManamy, and McQueen (1943).

ples at 120 to 130 feet in depth. A graphic section based on the sample study is shown in text figure 2. The map (fig. 1) is based on the published state geologic maps of Tennessee (1923), Kentucky (1929), Arkansas (1929) and Missouri (1939) and the preliminary edition of the new geologic map of

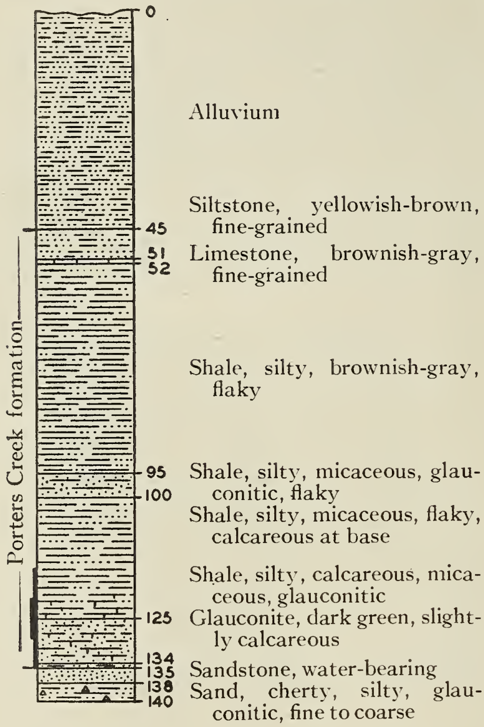


Fig. 2.—Graphic section showing the beds encountered in the Cache well and the fossiliferous zone indicated by the heavy border at the left margin.

Illinois (Weller, 1939), with some modifications in Missouri. Mr. J. E. Lamar contributed to the stratigraphic discussion.

FAUNAL DISCUSSION

The fauna from the Cache well consists of 30 species of the smaller Foraminifera, of which more than half (16 species) belong to the family Lagenidae. This is in accord with conclusions based on studies of Eocene foraminifera by Plummer (1927, p. 12), Cushman (1940), and Toulmin (1941). The other families represented are: Ellipsoidinidae and Anomalinidae, 4 species each; and Heterochilicidae, Rotaliidae, and Globigerinidae, 2 species each. Fifteen genera are represented.

The fauna is distinct from that in the Upper Cretaceous, which can be recognized by its preponderance of Textulariidae and, though very much like that of the Wilcox above, lacks the frequent occurrence of many species of the Miliolidae which characterizes the younger group.

SYSTEMATIC DESCRIPTIONS

Family LAGENIDAE Cushman

Genus CHRYSALIGONIUM Schubert

CHRYSALIGONIUM GRANTI (Plummer)

Plate 54, figures 26, 27

Nodosaria filiformis Carsey, 1926, Texas Univ. Bull. 2612, p. 33, vol. 7, fig. 8; Upper Cretaceous, Texas.

Nodosaria granti Plummer, 1927, Texas Univ. Bull. 2644, p. 83, pl. 5, figs. 9a–d; Midway group, Paleocene, Texas.

Dentalina granti, Plummer, 1931, Texas Univ. Bull. 3101, p. 149, pl. 11, figs. 8, 9; Upper Cretaceous, Texas.—Jennings, 1936, Bull. Am. Paleontology, vol. 23, p. 176, pl. 29, fig. 6; Upper Cretaceous, New Jersey.

Ellipsonodosaria granti, ? Cushman, 1936, Cushman Lab. Foram. Research Contr., vol. 2, p. 151, pl. 9, figs. 3–5; Upper Cretaceous, Texas and Arkansas.—Cushman, 1940, idem, vol. 16, p. 69, pl. 12, fig. 3; Midway group, Paleocene, Alabama.

Chrysaligonium granti, Toulmin, 1941, Jour. Paleontology, vol. 15, p. 589, pl. 79, figs. 34, 35; Salt Mountain limestone, Eocene, Alabama.

Test elongate, slender, slightly arcuate; chambers elongate, cylindrical; wall thick, smooth; suture flush with surface. Diameter of central chamber, 0.16 mm.; length about 0.28 mm.

This form, even though the species is somewhat variable, shows the general characteristics. The fragment (pl. 54, fig. 27) shows the apical spine. Its presence in Upper Cretaceous and lower Wilcox beds make it valueless as an index.

Genus DENTALINA d'Orbigny

DENTALINA cf. D. COMMUNIS (d'Orbigny)

Plate 55, figure 10

Nodosaria (*Dentalina*) *communis* d'Orbigny, 1826, Soc. Nat. Sci. Ann., vol. 7, p. 254, no. 35.

Nodosaria communis, Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 75, pl. 12, figs. 3, 4; Recent, Atlantic.

Faunal List and Geologic Range

Species	Pl. fig.	Previous known range
LAGENIDAE		
Chrysaligonium granti (Plummer)	54; 16, 27	Upper Cretaceous—Eocene
Dentalina cf. *D. communis* (d'Orbigny)	55; 20	Eocene—Recent
Dentalina cf. *D. cooperensis* Cushman	54; 21	Eocene
Dentalina pauperata d'Orbigny	54; 10	Jurassic–Recent?
Dentalina spira Cooper, n. sp.	54; 1, 2	
Lagena laevis (Montagu)	54; 6, 7	Eocene–Recent
Nodosaria latejugata Gümbel	55; 24, 25	Eocene–Oligocene
Nodosaria spinocostata Cooper, n. sp.	54; 11	
Nodosaria cf. *N. vertebralis* (Batsch)	55; 14, 15	Cretaceous–Recent
Nodosaria cf. *N. zippei* Reuss	55; 18, 19	Cretaceous
Palmula meglameryae Toulmin	55; 20, 21	Paleocene–Eocene
Robulus inornatus (d'Orbigny)	55; 26, 27	Eocene–Miocene
Robulus magnificus Toulmin	55; 1, 2	Eocene
Robulus midwayensis (Plummer)	55; 22, 23	Paleocene–Eocene
Vaginulina gracilis Plummer	55; 5, 6	Paleocene
Vaginulina robusta Plummer	55; 16, 17	Paleocene
HETEROHELICIDAE		
Rectogümbelina alabamensis Cushman	55; 3, 4	Paleocene
Siphonogeneroides? *eleganta* (Plummer)	54; 14	Paleocene
ELLIPSOIDINIDAE		
Ellipsonodosaria lepidula (Schwager)	54; 23	Upper Cretaceous–Pliocene
Ellipsonodosaria plummerae Cushman	54; 18, 19	Paleocene
Ellipsonodasaria sagrinensis (Bagg)	54; 22	Paleocene–Pliocene
Ellipsonodosaria spinulosa (Plummer)	54; 20	Paleocene
ROTALIIDAE		
Eponides exigua limbata (Plummer)	55; 11–13	Paleocene
Siphonina prima Plummer	55; 7–9	Cretaceous–Paleocene
GLOBIGERINIDAE		
Globigerina compressa Plummer	54; 8, 9	Paleocene–Eocene
Globigerina triloculinoides Plummer	54; 12, 13	Paleocene–Eocene
ANOMALINIDAE		
Anomalina acuta Plummer	54; 3–5	Paleocene–Eocene
Anomalina midwayensis (Plummer)	54; 15–17	Paleocene
Cibicides alleni (Plummer)	54; 24, 25	Cretaceous–Paleocene
Cibicides vulgaris (Plummer)	54; 28, 29	Paleocene

Dentalina communis, Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull. 2, p. 24, pl. 6, fig. 8; Upper Eocene, Louisiana.—?Cushman and Garrett, 1932, Cushman Lab. Foram. Research Contr., vol. 8, p. 55, pl. 7, figs. 12, 13; Wilcox group, Eocene, Alabama.—?Cushman and Garrett, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 80, pl. 14, figs. 1–3; Wilcox group, Eocene, Alabama.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 584, pl. 79, fig. 13; Salt Mountain limestone, Alabama.

Test elongate, slightly tapered, almost straight; sutures somewhat indistinct, inclined to axis; average diameter, 0.13 mm.; length (5 chambers), 0.39 mm.

This fragment is referred to this common Wilcox species with some doubt. It is not recorded in the Midway of Texas or Alabama.

Dentalina cf. D. cooperensis Cushman
Plate 54, figure 21

Dentalina cooperensis Cushman, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 8, pl. 1, fig. 17; Upper Jackson, Eocene, southeastern Coastal Plain.—Cushman, 1935, U. S. Geol. Survey Prof. Paper 181, p. 20, pl. 8, figs. 3, 4; Eocene, Southeastern United States.

Test elongate, compressed, somewhat tapered, gently curved, apical end slightly pointed; sutures distinct, only very slightly oblique to axis; wall smooth; apical end pointed; diameter, 0.10 mm., length (6 chambers), 0.45 mm.

This specimen, like that of *D. communis*, is of doubtful affinity and is questionably referred to this species.

DENTALIA cf. D. PAUPERATA d'Orbigny
Plate 54, figure 10

Dentalina pauperata d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. 1, figs. 57, 58.—Bournemann, 1855, Zeit. deutsch. geol. Gesell., vol. 7, p. 324, pl. 13, fig. 7.—Sherborn and Chapman, 1886, Roy. Micr. Soc. Jour., p. 750, pl. 15, fig. 9.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 58, pl. 10, fig. 15; Midway group, Paleocene, Alabama.

Nodosaria pauperata, H. B. Brady, 1884, Challenger, vol. 9 (zool.), p. 500, text fig. 14.—Chapman, 1893, Roy, Micr. Soc. Jour., p. 588, pl. 8, fig. 32.—Cushman, 1913, U. S. Nat. Mus. Bull. 71, pt. 3, p. 51, pl. 25, fig. 7.—Halkyard, 1917, Proc. Manchester Lit. Phil. Soc. Mem., vol. 62, no. 6, p. 71, pl. 4, figs. 8, 9.—Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 72, pl. 14, fig. 13.—Plummer, 1927, Texas Univ. Bull. 2644, p. 79, pl. 4, fig. 11; Midway group, Paleocene, Texas.

Test elongate, slightly tapered; chambers slightly arcuate, short, wide; initial chamber narrower, longer than those above, with terminal spine; walls smooth; sutures fairly prominent, transverse; average diameter, 0.33 mm.

This long ranged species, abundant in the Midway of Texas and Alabama, has no value as a marker.

DENTALINA SPIRA Cooper, n. sp.
Plate 54, figures 1, 2

Chambers globular, almost spherical; surface marked by 14 wide prominent ribs, some of which may not continue over entire length of chamber, tapering and merging with shell surface near sutures; somewhat spiral in arrangement when viewed from above; diameter, 1.25 mm.; height (one chamber), 1.2 mm.

D. spira does not appear to conform to any known species of *Dentalina* in the character and spiral arrangement of the ribs.

Genus LAGENA Walker and Jacob
LAGENA LAEVIS (Montagu)
Plate 54, figures 6, 7

Serpula (Lagena) laevis ovalis Walker and Boys, 1784, Test. Min. p. 3, pl. 1, fig. 9.

Vermiculum laeve, Montagu, 1803, Test. Brit., p. 524.

Lagena laevis, Cushman, 1913, U. S. Nat. Mus. Bull. 71, pt. 3, p. 5, pl. 1, fig. 3, pl. 38, fig. 5; Recent, Pacific.—Howe, 1939, Louisiana Dept. Cons. Geol. Bull. 14, p. 50, pl. 6, fig. 12; Claiborne group, Eocene, Louisiana.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 593, pl. 80, fig. 7; Salt Mountain limestone, Eocene, Alabama.

Test almost globular, slightly elliptical in lateral view; neck cylindrical, set abruptly on chamber; wall smooth; diameter 0.40 mm., length, probably 0.60–0.70 mm.

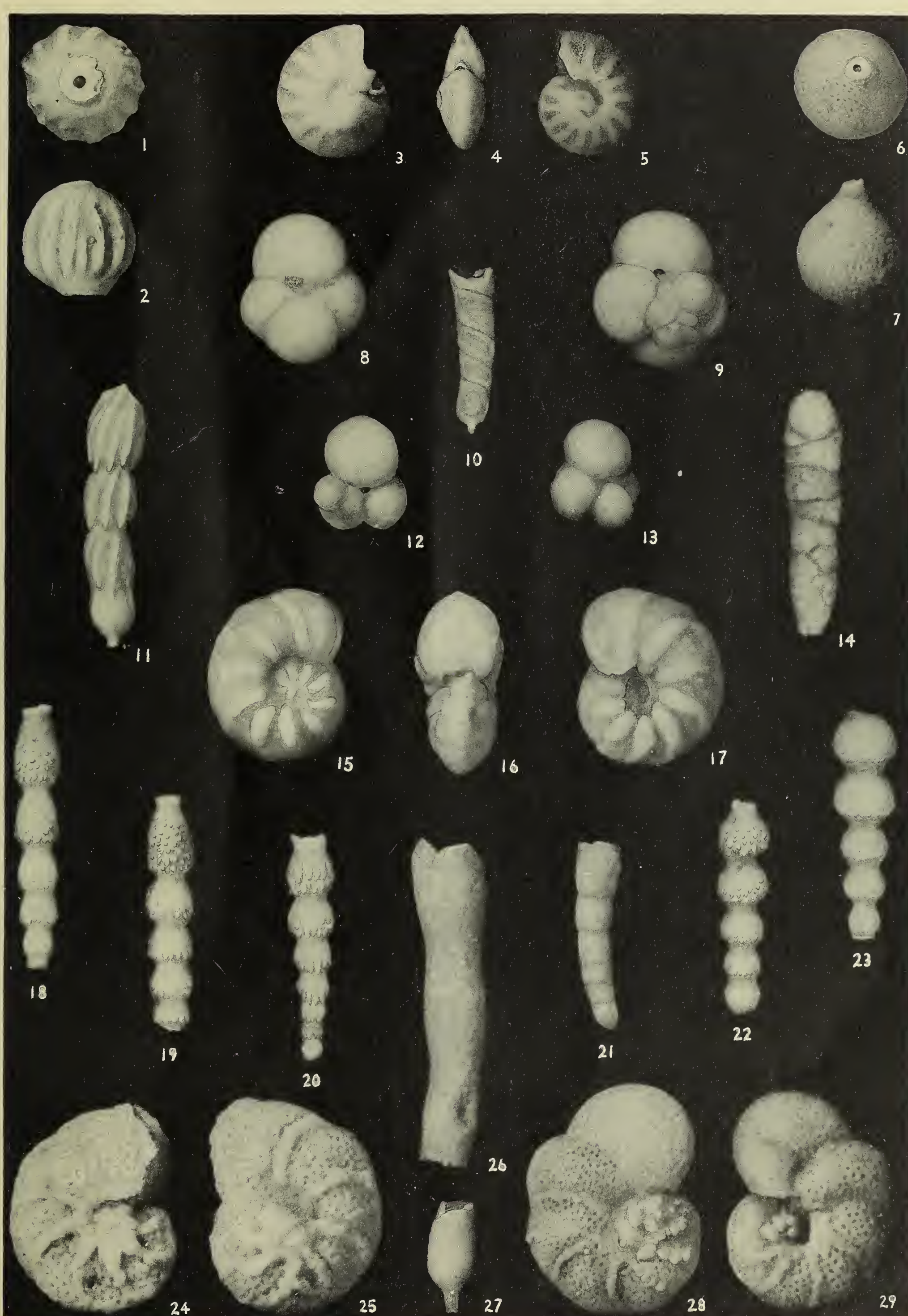
Although not known from the Cretaceous, this species ranges throughout the Tertiary.

Genus NODOSARIA Lamark
NODOSARIA LATEJUGATA Gümbel
Plate 55, figures 24, 25

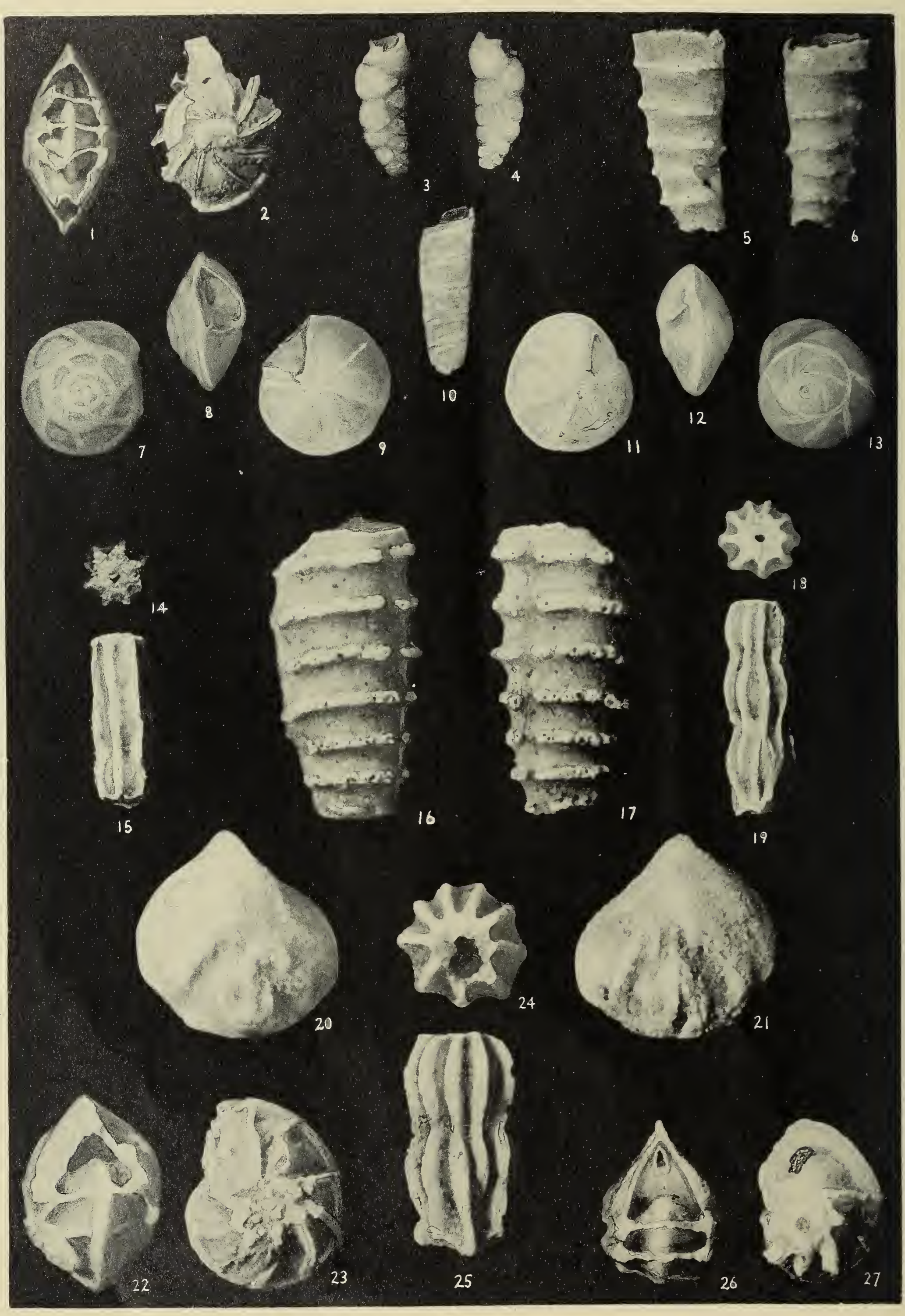
Nodosaria latejugata Gumbel, 1870, K. bayer. Akad. Wiss. München, Cl. 2, Abh., vol. 10,

EXPLANATION OF PLATE 54

FIGS. *1, 2*—*Dentalina spira* Cooper, n. sp. *1*, Sideview; *2*, top view, ×20. (p. 348)
3–5—*Anomalina acuta* Plummer. *3*, Ventral view; *4*, peripheral view; *5*, dorsal view, ×90. (p. 353)
6, 7—*Lagena laevis* (Montagu). *6*, Apertural view; *7*, lateral view, ×60. (p. 348)
8, 9—*Globigerina compressa* Plummer. *8*, Ventral view; dorsal view, ×90. (p. 353)
10—*Dentalina* cf. *D. pauperata* d'Orbigny, ×90. (p. 348)
11—*Nodosaria spinocostata* Cooper, n. sp., ×60. (p. 349)
12, 13—*Globigerina triloculinoides* Plummer, ×90 (p. 353)
14—*Siphogeneroides? eleganta* Plummer, ×90. (p. 351)
15–17—*Anomalina midwayensis* (Plummer). *15*, Dorsal view; *16*, peripheral view; *17*, ventral view, ×90. (p. 354)
18, 19—*Ellipsonodosaria plummerae* Cushman. ×90. (p. 352)
20—*Ellipsonodosaria spinulosa* (Plummer). ×90. (p. 352)
21—*Dentalina* cf. *D. cooperensis* Cushman. ×90. (p. 347)
22—*Ellipsonodosaria saginensis* (Plummer). ×90. (p. 352)
23—*Ellipsonodosaria lepidula* (Schwager). ×90. (p. 352)
24, 25—*Cibicides alleni* (Plummer). *24*, Ventral view; *25*, dorsal view. ×60. (p. 354)
26, 27—*Chrysaligonium granti* (Plummer). ×90. (p. 346)
28, 29—*Cibicides vulgaris* (Plummer). *28*, Dorsal view; *29*, ventral view. ×60. (p. 354)



Cooper—Paleocene Foraminifera



Cooper—Paleocene Foraminifera

p. 619, pl. 1, fig. 32; Upper Eocene, Bavaria.—Hankten, 1876, Magy. kir. fäldt. int. Évköuyoe, vol. 4, p. 21, pl. 2, figs. 6a–d; Eocene, Alabama.—Cushman, 1925, Cushman Lab. Foram. Research Contr., vol. 1, p. 66, pl. 10, fig. 7; Eocene, Alabama.—Cushman and Hanna, 1927, San Diego Soc. Nat. Hist. Trans., vol. 5, no. 4, p. 52, pl. 5, figs. 1–3; LaJolla formation, Eocene, California.—Cushman, 1935, U. S. Geol. Survey Prof. Paper 181, p. 21; Upper Eocene, U. S. Coastal Plain.—Cushman and McMasters, 1936, Jour. Paleontology, vol. 10, p. 512, pl. 75, figs. 11, 12; Middle Eocene, California.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 588, pl. 79, figs. 26, 27; Salt Mountain limestone, Eocene, Alabama.

Nodosaria affinis Plummer, 1927, Texas Univ. Bull. 2644, p. 89, pl. 14, figs. 2a–d; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 59, pl. 10, figs. 30–33; Midway group, Paleocene, Alabama.

Nodosaria burdensis Hankten, 1876, Magy. kir. fäldt. int. Évköuyoe, vol. 4, p. 23, pl. 2, fig. 10, pl. 16, fig. 4.

Nodosaria vertebralis Nuttall, 1932, Jour. Paleontology, vol. 6, p. 15, pl. 3, fig. 9; Alazan shale, Lower Oligocene, Tampico Embayment, Mexico.

Nodosaria sp. A, Israelsky, 1939, Sixth Pacific Sci. Cong. Proc. vol. 2, p. 575, pl. 3, fig. 11; Marysville formation, Eocene, California.

Test straight; chambers broad, only slightly inflated; with 9 strong longitudinal costate which continue across sutures and are normal to surface of chamber; sutures transverse; diameter 1.2 mm.; length (2 chambers), 2.0 mm.

This very strongly ribbed form seems quite variable in its specific characters. The fragmentary specimen figures represents one of the largest assigned to this species although it has the minimum number of costae. It is very common in Eocene sediments, especially in the lower formations. While quite similar to the Cretaceous *N. zippei* Reuss it differs from *N. affinis* Reuss, which has according to the original description only 4 to 5 costae.

NODOSARIA SPINOCOSTATA Cooper, n. sp.
Plate 54, figure 11

Nodosaria spinulosa Plummer (part), 1927, Texas Univ. Bull. 2644, p. 84, pl. 4, fig. 19c only; Midway group, Paleocene, Texas.

Ellipsonodosaria alexanderi, Cushman (part), 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 69, pl. 11, figs. 27, 29 only; Midway group, Paleocene, Texas.

Test elongate, slightly curved; chambers elongate to globular, increasing in size and length upward; initial chamber smaller than one next above, free of costae, terminated by relatively large spine; costae on succeeding chambers nine or less, discontinuous, each terminating in spine overhanging constricted region of sutures; average diameter, 0.20 mm.; length (3 chambers), 0.75 mm.

This species differs from *N. spinulosa* (Montagu) of various authors and *E. alexanderi* Cushman in that it is regularly costate as in *N. latejugata* Gümbel and others of this type, but the costae of *N. spinocostata* end in spines as shown by Plummer (1927, p. 4, fig. 19c) and Cushman (1940, pl. 11, figs. 27, 29). The holotype of *E. alexanderi* Cushman (1936, pl. 9, fig. 9) shows the characteristically irregular distribution of the spines over the entire surface of the chamber wall.

EXPLANATION OF PLATE 55

FIGS. *1, 2*—*Robulus magnificus* Toulmin. *1*, Peripheral view; *2*, dorsal view. ×20. (p. 350)
3, 4—*Rectogümbelina alabamensis* Cushman. ×90. (p. 351)
5, 6—*Vaginulina gracilis* Plummer. ×60. (p. 351)
7–9—*Siphonina prima* Plummer. *7*, Dorsal view; *8*, peripheral view; *9*, ventral view. ×90. (p. 353)
10—*Dentalina* cf. *D. communis* (d'Orbigny). ×90. (p. 346)
11–13—*Eponides exigna limbata* Plummer. *11*, Ventral view; *12*, peripheral view; *13*, dorsal view. ×90. (p. 353)
14, 15—*Nodosaria* cf. *N. vertebralis* (Batsch). *1*, Top view of broken specimen; *2*, lateral view of three chambers. ×20. (p. 350)
16, 17—*Vaginulina robusta* Plummer. Opposite sides of one specimen. ×40. (p. 351)
18, 19—*Nodosaria zippei* Reuss. Top and lateral views. ×20. (p. 350)
20, 21—*Palmula mcglamerae* Toulmin. Opposite views of one specimen. ×40. (p. 350)
22–23—*Robulus midwayensis* (Plummer). *22*, Peripheral view; *23*, dorsal view. ×40. (p. 351)
24–25—*Nodosaria latejugata* Gümbel. *24*, Top view, broken along suture; *25*, lateral view. ×20. (p. 348)
26–27—*Robulus inornatus* (d'Orbigny). *26*, Peripheral view of broken shell showing the oval, slit-like aperature; *27*, dorsal view. ×40. (p. 350)

NODOSARIA cf. N. VERTEBRALIS (Batsch)
Plate 55, figures 14, 15

Nautilus (*Orthoceras*) *vertebralis* Batsch, 1791, Conch. des Seesandes no. 6, p. 3, pl. 2, fig. 6; Recent, Mediterranean.
Nodosaria vertebralis, H. B. Brady, 1884, Challenger, vol. 9 (Zool.), p. 514, pl. 63, fig. 35; pl. 64, figs. 11–14; Recent.—Flint, 1899, U. S. Nat. Mus. Ann. Rept. for 1897, p. 312, pl. 57, fig. 5; Recent.—Bagg, 1912, U. S. Geol. Survey Bull. 513, p. 60, pl. 17, fig. 2; Pliocene and Pleistocene, California.—Cushman, 1913, U. S. Nat. Mus. Bull. 71, pt. 3, p. 60, pl. 32, fig. 1; Recent, North Pacific.—Cushman, 1919, Carnegie Inst. Washington Pub. 291, p. 35, pl. 7, figs. 3–5; Recent, Caribbean and tropical Pacific, West Indies.—Cushman, 1919, U. S. Nat. Mus. Bull. 100, vol. 4, p. 211, pl. 38, figs. 2, 3; pl. 40, fig. 2; Recent, Philippine Archipelago.—Cushman, 1923, idem., Bull. 104, pt. 4, p. 86, pl. 14, fig. 6; Recent, Gulf of Mexico.—Plummer, 1927, Texas Univ. Bull. 2644, p. 88, pl. 5, fig. 10; Midway group, Paleocene, Texas.

This fragment showing three chambers seems closest to *N. vertebralis* by reason of the few continuous ribs and the almost total lack of inflation of the valves. It is common in the lower Midway of Texas but the species is known to range from the Cretaceous to Recent.

NODOSARIA cf. N. ZIPPEI Reuss
Plate 55, figures 18, 19

Nodosaria zippei Reuss, 1844, Geogn. Skizze aus Böhmer, p. 210.—Reuss, 1845, Die Versteinerungen der böhemischen Kreide, pt. 1, p. 25, pl. 8, figs. 1–3; Cretaceous, Bohemia.—Beissel and Halzapfel, 1891, Abh. d. geol. Landesanstalt, n. ser., no. 3, pt. 6, pp. 31, 32, figs. 10–29, pl. 16, fig. 32.—Egger, 1899, Abh. d. II, Ck. d. k. Ak. d. Wiss, vol. 21, pt. 1, p. 78, pl. 8, fig. 3.—Plummer, 1931, Texas Univ. Bull. 3101, p. 157; Cretaceous, Texas.—Sandidge, 1932, Jour. Paleontology, vol. 6, p. 275, pl. 42, figs. 13, 14; Ripley formation, Cretaceous, Texas.—Jennings, 1936, Bull. Am. Paleontology, vol. 23, p. 178, pl. 2, fig. 13. Navisink formation, Cretaceous, New Jersey.

Test elongate, straight; chambers numerous; globular, separated by prominent, deeply incised, transverse sutures; ribs 9, raised, fin-like, rarely fused, more frequently abruptly terminated; diameter, 0.8 mm.; length (2 chambers), 0.17 mm.

The specimen illustrated has been referred to this species because of the joining or fusing of some costae and the termination of others; both features are shown in figure 19. This specimen is classified with *N. zippei* with some hesitancy because all other described forms are from the Cretaceous.

Genus PALMULA Lea
PALMULA MCGLAMERYAE Toulmin
Plate 55, figures 20, 21

Palmula mcglameryae Toulmin, 1941, Jour. Palaeontology, vol. 15, p. 592, pl. 80, figs. 1–3; Salt Mountain limestone, Eocene, Alabama.
Polymorphina cushmani Plummer, 1927, Texas Univ. Bull. 2644, p. 125, pl. 6, fig. 9.

Test wide, compressed, thickest through rounded base; periphery irregular or asymmetric, rounded on basal margin, produced to point on aperatural end; width, 1.1 mm.; height, 1.2 mm.

Although the distal end is more rounded than the form illustrated by Plummer, Toulmin (1941) in his three figures and in his remarks demonstrates the great variability of the outline of this species.

Genus ROBULUS Montfort
ROBULUS INORNATUS (d'Orbigny)
Plate 55, figures 26, 27

Robulina inornata d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 102, pl. 4, figs. 25, 26; Miocene, Austria.
Cristellaria inornata, Cushman and Hanna, 1927, California Acad. Sci. Proc., ser. 4, vol. 16, p. 217, pl. 14, fig. 5; Eocene, California.—Nuttall, 1932, Jour. Paleontology, vol. 6, p. 10; Eocene, Mexico.—Palmer and Bermúdez, 1936, Soc. Cubana Hist. Nat. Mem., vol. 10, no. 4, p. 249; Oligocene, Cuba.
Robulus inornatus, Cushman and Backsdale, 1930, Stanford Univ. Dept. Geol. Contr., vol. 1, no. 2, p. 62, pl. 11, figs. 2, 3; Eocene, California.—?Israelsky, 1939, Proc. Sixth Pacific Sci. Cong., p. 573, pl. 3, fig. 1; Marysville formation (Capay stage), Eocene, California.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 577, pl. 78, fig. 19, text fig. 2B; Salt Mountain limestone, Eocene, Alabama.

Test large, somewhat compressed, thickness three-fourths of diameter, closely coiled, periphery acutely keeled; chambers 7 in last whorl, triangular in outline, increasing rapidly in size to final one; sutures distinctly limbate, slightly curved, tangent to large umbo; diameter, 1.0 mm.; thickness, 0.75 mm.

ROBULUS MAGNIFICUS Toulmin
Plate 55, figures 1, 2

Robulus magnificus Toulmin, 1941, Jour. Paleontology, vol. 15, p. 578, pl. 78, fig. 22, text fig.

2D; Salt Mountain limestone, Eocene, Alabama.

Test compressed, thickness about one-half of diameter; periphery distinctly keeled in early chambers, less so in final ones; chambers 9 in last whorl; sutures almost straight to slightly curved, raised, distinctly limbate, subtangent to, but not meeting umbo in final two or three chambers; diameter, 2.0 mm.; thickness, 1.1 mm.

This form seems identical with *R. magnificus* described by Toulmin from Alabama, except that the sutures of the Illinois specimen are somewhat less curved.

Robulus midwayensis (Plummer)
Plate 55, figures 22, 23

Cristellaria midwayensis Plummer, 1927, Texas Univ. Bull. 2644, p. 95, pl. 13, figs. 5a–c; Midway group. Paleocene, Texas.
Lenticulina midwayana Israelsky, 1939, Proc. Sixth Pacific Sci. Cong., p. 573, pl. 2, figs. 7, 8; Marysville formation (Capay stage), Eocene, California.
Robulus midwayensis Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 54, pl. 9, fig. 12; Midway group, Paleocene, Alabama.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 579, pl. 78, fig. 23, text fig. 2G; Salt Mountain limestone, Eocene, Alabama.

Test large, only slightly compressed, diameter and thickness about equal; chambers 9 in last whorl; slightly curved, almost equal in size, increasing very gradually to final chamber; sutures prominent, limbate, tapering, with greatest curvature near peripheral margin; diameter and thickness, about 1.2 mm.

The Illinois specimen is nodose and thus resembles the Texas form but Salt Mountain specimens have a smooth umbo. This species is a good Midway marker in Texas.

Genus Vaginulina d'Orbigny
Vaginulina gracilis Plummer
Plate 55, figures 5, 6

Vagulina gracilis Plummer, 1927, Texas Univ. Bull. 2644, p. 111, pl. 6, figs. 5a–b; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 61, pl. 9, fig. 27; Midway group, Paleocene, Alabama.

Test tapering, slightly arcuate, compressed; chambers short; sutures only slightly oblique, marked by abrupt, narrow, somewhat nodose and discontinuous ridges; diameter, average, 0.3 mm; height, 5 chambers, 0.50 mm.

This species is common in the lower Midway of Alabama and Texas, where it is succeeded in the upper Midway by *V. robusta* Plummer.

Vaginulina robusta Plummer
Plate 55, figures 16, 17

Vaginulina robusta Plummer, 1927, Texas Univ. Bull. 2644, p. 112, pl. 6, figs. 4a–b, pl. 13, fig. 3; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 61, pl. 10, figs. 1–4; Midway group, Paleocene, Alabama.

Test, large, robust, slightly compressed; straight; chambers smooth, short but quite broad; sutures transverse to slightly oblique, prominent, somewhat nodose; nodes discontinuous along more convex edges (in double row on broader edge, see figs. 16, 17); average diameter, 0.8 mm; height, 5 chambers, 1.3 mm.

This species is characteristic of the upper Midway in Texas and Alabama. It is straighter and more robust than *V. gracilis.*

Family Heterohelicidae Cushman
Genus Rectogümbelina Cushman
Rectogümbelina alabamensis Cushman
Plate 55, figures 3, 4

Rectogümbelina alabamensis Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 65, pl. 11, fig. 16; Midway group, Paleocene, Alabama.

Test very small, slightly arcuate, slender, tapering; early chambers biserial, later ones uniserial, biserial chambers less inflated; early sutures slightly and less depressed than later ones; diameter 0.065–0.145 mm.; length, 0.37.

Although slightly larger than the form described by Cushman from Alabama, the Illinois specimen seems to conform in all other respects. Common in the upper Midway of Alabama.

Genus Siphogeneroides Cushman
Siphogeneroides? eleganta (Plummer)
Plate 54, figure 14

Siphogenerina eleganta Plummer, 1927, Texas Univ. Bull. 2644, p. 126, pl. 8, figs. 1a–c; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 66, pl. 11, fig. 17; Midway group, Paleocene, Alabama.

Test small, elongate, straight, tapering; early chambers indistinct, may be bi- or triserial, later chambers irregular in size and shape, arranged alternately in oblique manner; sutures distinct, sharply incised; aperature terminal; diameter, 0.072–0.15 mm.; length, 0.50 mm.

This species, which is placed in synonymy with *Siphogenerina eleganta* Plummer by Cushman, is described as biserial by Plummer and triserial by Cushman. The early chambers of the Illinois specimen are too indistinct for accurate determination. It is common in the upper Midway of Texas and the lower Midway of Alabama.

Family Ellipsoidinidae

Genus Ellipsonodosaria A. Silvestri

Ellipsonodosaria lepidula (Schwager)

Plate 54, figure 23

Nodosaria lepidula Schwager, 1866, Novara-Exped. Geol. Theil., vol. 2, p. 210, pl. 5, figs. 27–28; Pliocene.—Galloway and Morey, 1929, Bull. Am. Paleontology, vol. 15, no. 55, p. 17, pl. 2, fig. 2; Eocene, Ecuador.—Galloway and Morey, 1931, Jour. Paleontology, vol. 5, p. 337, pl. 38, fig. 1, Upper Cretaceous, Mexico.

Ellipsonodosaria sp. Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 70, pl. 12, figs. 1, 2; Midway group, Paleocene, Alabama.

Test elongate, tapering, straight; chambers globular, smooth except that for lower margin is angular, fimbriate; diameter, 0.078–0.17 mm.; length, 5 chambers, 0.55 mm.

E. lepidula is distinguished by the globular, almost spherical chambers, which are connected by short "necks," and which are smooth except for a very narrow fimbriate margin on the lower edge. Rare in the late Cretaceous of Mexico and the lower Midway of Alabama.

Ellipsonodosaria plummerae Cushman

Plate 54, figures 18, 19

Ellipsonodosaria plummerae Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 69, pl. 12, figs. 4, 5; Midway group, Pliocene, Texas.

Test elongate, somewhat tapering, straight; chambers pyriform, distinct, increasing in size and becoming more pyriform upward, very spinose, especially at ridge near base of chamber; aperture terminal, rounded, phialine; diameter, 0.078–0.13 mm., length, 5 chambers, 0.61 mm.

This species seems very close to *E. pseudoscripta* Cushman from the Upper Cretaceous and to *E. sagrinensis* (Bagg) from the Midway. It differs from the latter, however, in its more elongate chambers and from the former by the more abrupt margins on the lower edges of the chambers.

Ellipsonodosaria sagrinensis (Bagg)

Plate 54, figure 22

Nodosaria sagrinensis Bagg, 1912, U. S. Geol. Survey Bull. 513, p. 58, pl. 16, fig. 4; Pliocene, California.—Plummer, 1927, Texas Univ. Bull. 2644, p. 85, pl. 4, fig. 16; Midway group, Paleocene, Texas.

Nodogenerina sagrinensis Jennings, 1936, Bull. Am. Paleontology, vol. 23, p. 187, pl. 3, fig. 17; Hornerstown, Eocene, New Jersey.

Test straight, tapered; chambers short to globular in early stages, becoming more elongate later, lower edge fimbriate, upper part narrowing toward sutures, wall thickly spinose; spines short above, longer below, overhanging lower edge; sutures deep, broad; average diameter, 0.10 mm.; length, 5 chambers, 0.50 mm.

This species was placed in synonymy with *E. plummerae* by Cushman (1940, p. 69) but its chambers do not seem to be sufficiently elongate to warrant its reference to that species. It is abundant in the upper, but rare to common in the lower Midway of Texas, and has also been reported from the Navarro.

Ellipsonodosaria spinulosa (Plummer)

Plate 54, figure 20

Nodosaria spinulosa (part) Plummer, 1927, Texas Univ. Bull. 2644, p. 85, pl. 4, fig. 19a, b only; Midway, Paleocene, Texas.

Test elongate, tapering, straight to slightly arcuate; chambers somewhat elongate, covered with spine-terminated ribs; sutures depressed; average diameter, 0.10 mm.; height, 7 chambers, 0.50 mm.

This form differs from *Nodosaria spinocostata* n. sp. and from *N. spinulosa* Plummer (1927, pl. 4, fig. 19c), in that its ribs may terminate in spines over the entire chamber wall while in *N. spinocostata* the ribs occupy the entire length of the chamber wall and terminate in a spine overhanging the sutural depression.

Family ROTALIIDAE Reuss
Genus EPONIDES Montfort
EPONIDES EXIGUA LIMBATA (Plummer)
Plate 55, figures 11–13

Pulvinulina exigua limbata Plummer, 1927, Texas Univ. Bull. 2644, p. 152, pl. 11, figs. 4a–c; Midway group, Paleocene, Texas.
?Eponides sp. Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 71, pl. 12, figs. 8a, b; Midway group, Paleocene, Alabama.

Test small, biconvex, peripheral margin sharp or acute, indistinctly lobed, chambers 5 in final whorl, smooth; sutures very indistinct, on dorsal side oblique, straight, narrow; ventral sutures flush, almost straight but slightly curved from umbilicus; diameter, 0.30 mm.; thickness, 0.20 mm.

This species and its two varieties are common in the Midway of Texas. The variety *limbata* is common in the basal strata and var. *exigua* forms a good marker for the lower beds. The Alabama form is limited to the upper Midway.

Genus SIPHONINA Reuss
SIPHONINA PRIMA Plummer
Plate 55, figures 7–9

Siphonina prima Plummer, 1927, Texas Univ. Bull. 2644, p. 148, pl. 12, figs. 4a–c; Midway group, Paleocene, Texas.—Cushman, 1927, U. S. Nat. Mus. Proc., vol. 72, art. 20, p. 2, pl. 2, figs. 4a–c.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 71, pl. 12, fig. 10; Midway group, Paleocene, Alabama; Navarro, Cretaceous, Gulf Coast Embayment.

Test circular, biconvex; peripheral angle acute; margin lobate, chambers 5 in last whorl; dorsal sutures curved, broad; ventral sutures straight, narrow, excavated, radiate from shallow central depressed area; diameter, 0.35 mm.; thickness, 0.20 mm.

It is common in the upper Midway of Texas, Alabama, Arkansas, Mississippi, and Tennessee, but is also present in the Upper Cretaceous (Navarro) in these states.

Family GLOBIGERINIDAE Carpenter
Genus GLOBIGERINA d'Orbigny
GLOBIGERINA COMPRESSA Plummer
Plate 54, figures 8, 9

Globigerina compressa Plummer, 1927, Texas Univ. Bull. 2644, p. 135, pl. 8, figs. 11a–c; Midway group, Paleocene, Texas.—Jennings, 1936, Bull. Am. Paleontology, vol. 23, p. 193. pl. 31, fig. 8; Hornerstown formation, Eocene, New Jersey.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 607, pl. 82, figs. 1, 2; Salt Mountain limestone, Eocene, Alabama.

Test small, quadrate, closely coiled, compressed, margin lobate; chambers increasing regularly, inflated, overlapping dorsally; sutures strongly depressed; wall thin, smooth, finely punctate; single aperature arched; diameter, 0.30 to 0.40 mm.

It is common in the upper Midway of Texas.

GLOBIGERINA TRILOCULINOIDES Plummer
Plate 54, figures 12, 13

Globigerina triloculinoides Plummer, 1927, Texas Univ. Bull. 2644, p. 134, pl. 8, figs. 10a–c; Midway group, Paleocene, Texas.—Jennings, 1936, Bull. Am. Paleontology, vol. 23, p. 193, pl. 31, fig. 10; Hornerstown formation, Eocene, New Jersey.—Glaessner, 1937, Moscow Univ. Publ. Lab. Paleontology, vols. 2–3, p. 382, pl. 4, figs. 33a, b; Lower Tertiary, Caucasus.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 72, pl. 12, fig. 15; Midway group, Paleocene, Alabama.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 607, pl. 82, fig. 3; Salt Mountain limestone, Eocene, Alabama.

Test very small, trochoid, periphery distinctly lobate; last volution formed by 3 large globular chambers which increase rapidly in size; surface finely punctate; diameter, 0.25 to 0.30 mm.

It is common in the upper Midway of Texas and Alabama and the Salt Mountain limestone of the Alabama Wilcox.

Family ANOMALINIDAE Cushman
Genus ANOMALINA d'Orbigny
ANOMALINA ACUTA Plummer
Plate 54, figures 3–5

Anomalina ammonoides acuta Plummer, 1927, Texas Univ. Bull. 2644, p. 149, pl. 10, figs. 2a–c; Midway group, Paleocene, Texas.
Anomalina acuta, Glaessner, 1937, Moscow Publ. Lab. Paleontology, vols. 2–3, p. 386, pl. 5, figs. 39a–c. Lower Tertiary, Caucasus.—Toulmin, 1941, Jour. Paleontology, vol. 15, p. 608, pl. 82, figs. 9, 10; Salt Mountain limestone (lower Wilcox).

Test compressed, involute, about equally biconvex, periphery acute; chambers narrow, numerous, 13 in last whorl; dorsal sutures distinct, limbate to slightly depressed; ventral sutures thickened around umbilical area, merging into prominently developed

or elevated central boss; shell perforate; diameter, 0.31 mm.; thickness, 0.12 mm.

This species is common in the two faunal zones of the Midway of Texas and serves to distinguish these horizons from the underlying Cretaceous formations. It also occurs in the lower Wilcox of Alabama.

Anomalina midwayensis (Plummer)
Plate 54, figures 15–17

Truncatulina midwayensis Plummer, 1927, Texas Univ. Bull. 2644, p. 141, pl. 9, figs. 7a–c, pl. 15, figs. 3a–b; Midway group, Paleocene, Texas.
Anomalina midwayensis, Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 73, pl. 12, fig. 18; Midway group, Paleocene, Texas.

Test biconvex, little compressed; chambers 9 to 10 in last whorl, punctate; sutures strongly elevated, broad near umbilicus but separated from it, tapering toward margin, curved; slit-like aperature at base of septal face; diameter, 0.41 mm., thickness, 0.22 mm.

This form is identical with the Texas Midway form in all respects except that it is somewhat thicker and the sutures a little wider, especially near the umbilicus. The species is found throughout the Midway of Texas and in the upper Midway of Alabama.

Genus Cibicides Montfort
Cibicides alleni (Plummer)
Plate 54, figures 24, 25

Truncatulina alleni Plummer, 1927, Texas Univ. Bull. 2644, p. 144, pl. 10, figs. 4a–c; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 73, pl. 12, fig. 19; Midway group, Paleocene, Alabama.

Test unequally biconvex, more rounded on ventral side; peripheral margin slightly acute, somewhat lobate; chambers, 9? in last whorl, coarsely punctate; sutures and periphery conspicuously marked by shell material; sutures curved, gently tapering from large, smooth umbilicus; aperature large, arched, extending far down on ventral side; diameter, 0.60 to 0.80 mm.

It is common in the middle and upper Midway of Texas and Alabama but is rare in the Navarro.

Cibicides vulgaris (Plummer)
Plate 54, figures 28, 29

Truncatulina vulgaris Plummer, 1927, Texas Univ. Bull. 2644, p. 145, pl. 10, figs. 3a–c; Midway group, Paleocene, Texas.—Cushman, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 73, pl. 12, fig. 21; Midway group, Paleocene, Alabama.

Test unequally biconvex; periphery broadly rounded, lobate; chambers 8 in last whorl, later ones turgid; sutures curved, tapering, elevated by shell material, walls coarsely punctate; slit-like aperature extending from periphery to umbilicus; diameter, 0.60 to 0.85 mm.

It is abundant in the upper and rare in the lower Midway of Alabama and Texas.

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